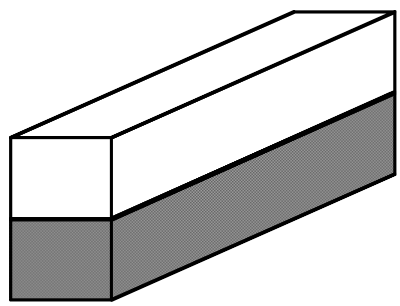
Georgia Institute of Technology
G.W. Woodruff School of Mechanical Engineerint
Acoustics Ph.D. Qualifying Examination
Fall 2007
Closed book

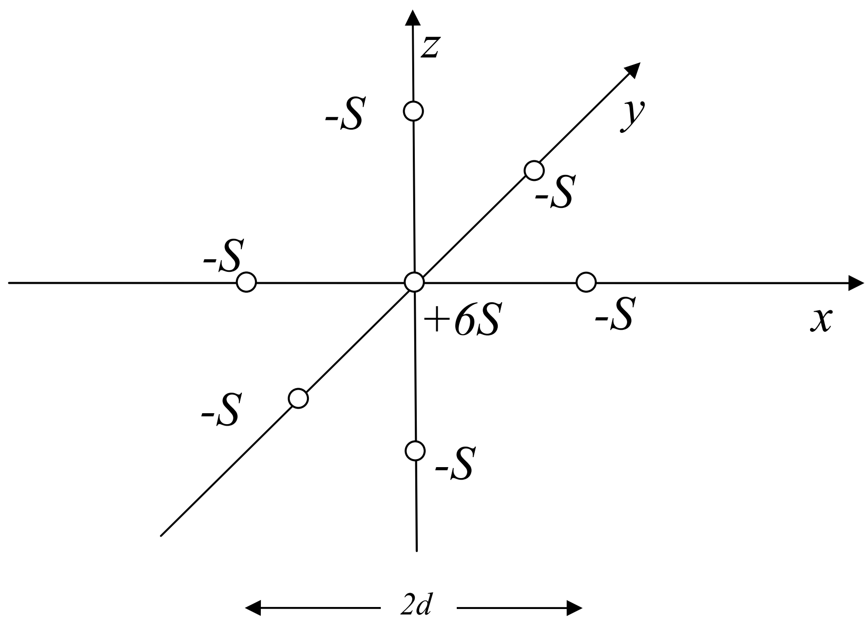
Answer all three questions

1. A rectangular cavity is half filled with water. The cavity has length of 4 meters, width of 1 m, and height of 2 m. Determine:

   a. For the air-filled space, the mode shapes (eigenfunctions) and an expression for the natural frequencies.

   b. For the water-filled space, the mode shapes (eigenfunctions) and an expression for the natural frequencies.





2. Six monopole acoustic sources with source strength - *S* and frequency ω are located *(0,0,d), (0,0,-d), (d,0,0), (-d,0,0), (0,d,0)* and *(0,-d,0)* as shown above. A seventh monopole with source strength +*6S* is located at the origin *(0, 0, 0*).

    a. What are the lowest order, nonzero multipole moments of this system?

    b. Show that this system is omnidirectional in the farfield, for $kd << 1$, What is the source strength of the system? How does this sound field differ from a monopole field?

    c. What is the minimum value for *kd* which would produce field with a null in the direction of the ± *x*-axis.

3. Consider a section of a tube of length *l* as shown below. At one end of the tube is a piston which is oscillating with a velocity $u(t) = U_o \cos(\omega t)$, and the other end is terminated with a material with an acoustic impedance of $Z_T = 5\ Z_o$, where Z_o is the acoustic impedance of air that fills the tube. You can assume that the frequency is low enough so that only the lowest propagating mode exists in the tube.

    a. Derive the expressions for particle velocity and pressure field distributions in the tube. Obtain the instantaneous energy flow and time-averaged value of the relevant components of sound intensity.

    b. Plot the velocity and pressure fields in the tube assuming $l = 1.25\ \lambda$, where λ is the acoustic wavelength. Calculate the time-averaged intensity for this case. In your plots clearly indicate the limiting values of velocity and pressure, and other important dimensions.

    c. Assume that the piston source is now moved closer to the termination, to $l = 1.05\ \lambda$. Repeat part b) by plotting the fields and calculate the sound intensity. Will there be any change in the field distribution or intensity? Comment on the results.